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THESIS

METHODOLOGY FOR MONITORING THE USMC PERFORMANCE EVALUATION SYSTEM

by

James B. Hill

March 1985

Thesis Advisor: Francis R. Richards

Approved for public release, distribution unlimited

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that the USMC Fitness Report Form (1610) contained sufficient information for decision making. A model describing fitness report inflation was formulated during development of monitoring methodology. This inflation model was derived heuristically from observations dealing with school grade inflation.

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Methodology for Monitoring the USMC Performance Evaluation System

by

James B. Hill
Captain, United States Marine Corps
B.E., Vanderbilt University, 1976

Submitted in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE IN OPERATIONS RESEARCH

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ABSTRACT

This study examines the usefulness of United States Marine Corps fitness report information to promotion boards and proposes methodology for monitoring the Marine Corps performance evaluation system. Factor analysis was used to reduce the dimensions associated with fitness report data and construct a discriminant analytic model describing the promotion decision. This decision model sucessfully predicted promotions from fitness report data and showed that the USMC Fitness Report Form (1610) contained sufficient information for decision making. A model describing fitness report inflation was formulated during development of monitoring methodology. This inflation model was derived heuristically from observations dealing with school grade inflation.

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I. USMC PERFORMANCE EVALUATION SYSTEM

The purpose of the Marine Corps performance evaluation system [Ref. 1] is to provide a means with which to periodically evaluate, counsel, and report performance, value and personal characteristics of Marines in the rank of sergeant and above. The performance evaluation system consists of the following elements:

a. Evaluated Marine, who submits duty preferences and checks administrative data.

b. Reporting officer, who observes the Marine's performance, provides counseling, and submits his observations/evaluations on a fitness report form.

c. Reviewing officer, who reviews each report for accuracy, completeness, and consistency.

d. Headquarters, Marine Corps, which screens, files and acknowledges receipt of each fitness report.

The performance evaluation system has four objectives.

A. OBJECTIVES

The most important objective of the system is to improve a Marine's performance. This is achieved by coupling the evaluation and submission of fitness reports with counseling sessions.

Another objective is to provide information to selection boards for use in identification of those Marines most qualified for promotion or competitive assignment. This is achieved by use of fitness reports.

The third objective of the system is to clearly indicate areas in which a Marine must improve in order to qualify for promotion. If applicable, each Marine receives this type of information during counseling sessions. Promotion boards obtain this kind of information from the markings and comments submitted on fitness reports. Subsequent reports allow promotion boards to note improvement and credit an individual Marine for his attitude and response.

The last objective of the performance evaluation system is to help a Marine maintain a career pattern, which (hopefully) satisfies his own desires as well as the personnel requirements of the Marine Corps. This goal is achieved in three steps. First, the Marine submits his duty preferences on his fitness report. Next, the reporting senior counsels the Marine about possible career effects and submits recommendations or reports suitability by means of fitness reports. Finally, the personnel management division considers this information while making assignments that meet the needs of the Marine Corps.

B. COUNSELING

Counseling is a continuous process which commences when a Marine joins a unit. It is conducted frequently throughout his tour, and ends upon detachment. Counseling normally covers three areas: performance of duties,

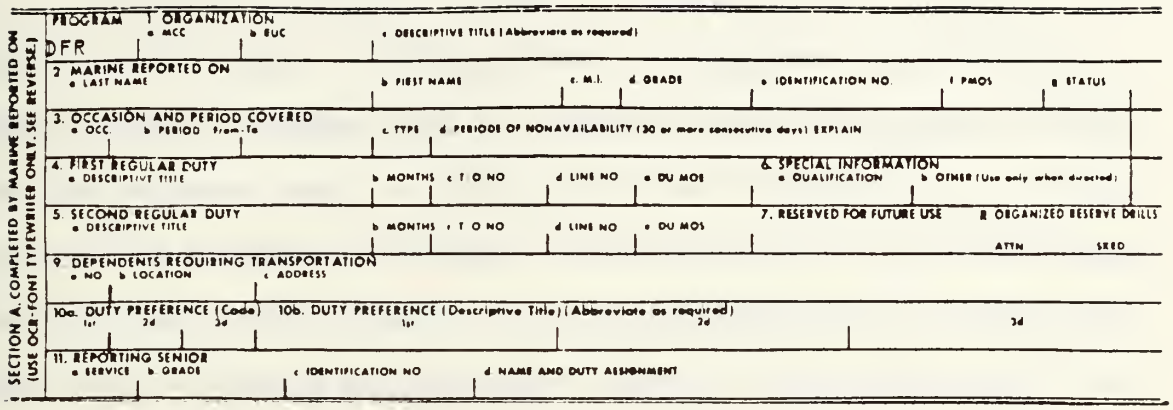
personal qualities, and career advancement. Sessions are generally specific in nature and include recommendations outlining corrective steps that can be taken to correct a deficiency or achieve a personal or career goal. Counseling sessions are the means by which Marines learn what is expected of them, how they are performing, and what they can do to improve.

C. USMC FITNESS REPORTS

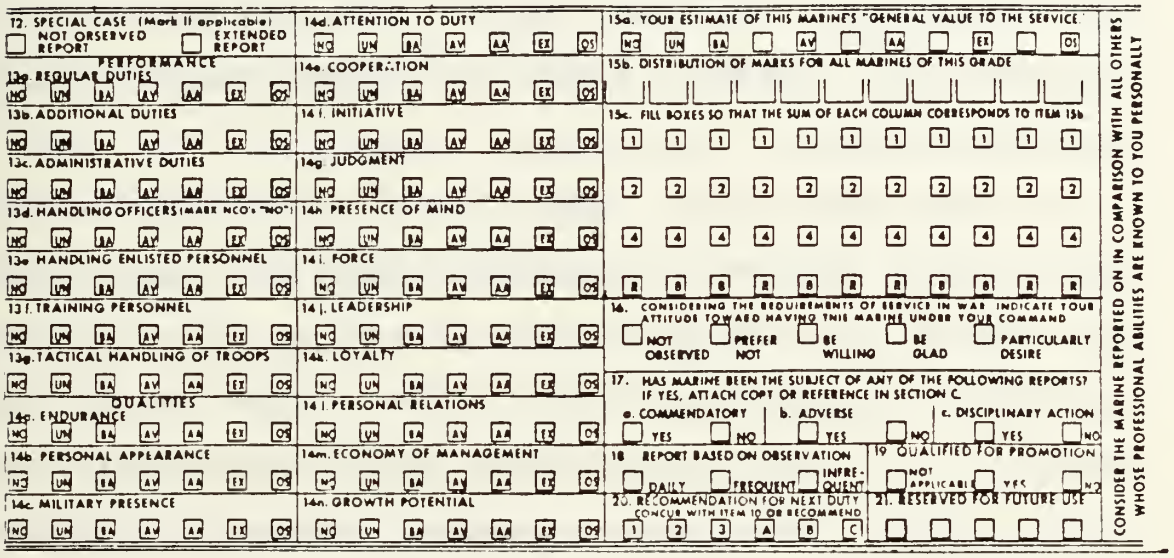
The Marine Corps fitness report form is used to aid the personnel assignment process and to assist selection boards in identifying eligible Marines most qualified for promotion. Although counseling is the means by which the performance evaluation system achieves improved performance and helps Marines qualify themselves for career advancement, the fitness report is the primary tool used to select an individual for assignment, retention and promotion. Fitness report information is submitted on USMC Form (1610). An extract is included as Figure 1.

The fitness report form contains three sections--each providing information about an individual Marine. Section A contains administrative information. Section B contains quantifiable ratings and recommendations concerning the Marines's performance of duty, personal qualities, value to the service, and other categories. Section C contains other information and explanations for Section B markings.

SECTION - A



SECTION - B


12. SPECIAL CASE (Mark if applicable)
NOT OBSERVED REPORT
EXTENDED REPORT
PERFORMANCE
13a. REGULAR DUTIES
13b. ADDITIONAL DUTIES
13c. ADMINISTRATIVE DUTIES
13d. HANDLING OFFICERS (MARK NCO's "NO")
13e. HANDLING ENLISTED PERSONNEL
13f. TRAINING PERSONNEL
13g. TACTICAL HANDLING OF TROOPS
QUALITIES
14a. ENDURANCE
14b. PERSONAL APPEARANCE
14c. MILITARY PRESENCE
14d. ATTENTION TO DUTY
14e. COOPERATION
14f. INITIATIVE
14g. JUDGMENT
14h. PRESENCE OF MIND
14i. FORCE
14j. LEADERSHIP
14k. LOYALTY
14l. PERSONAL RELATIONS
14m. ECONOMY OF MANAGEMENT
14n. GROWTH POTENTIAL
NO UN BA AV AA EX OS
15a. YOUR ESTIMATE OF THIS MARINE'S "GENERAL VALUE TO THE SERVICE"
15b. DISTRIBUTION OF MARKS FOR ALL MARINES OF THIS GRADE
15c. FILL BOXES SO THAT THE SUM OF EACH COLUMN CORRESPONDS TO ITEM 15b
16. CONSIDERING THE REQUIREMENTS OF SERVICE IN WAR INDICATE YOUR ATTITUDE TOWARD HAVING THIS MARINE UNDER YOUR COMMAND
NOT OBSERVED
PREFER NOT
BE WILLING
BE GLAD
PARTICULARLY DESIRE
17. HAS MARINE BEEN THE SUBJECT OF ANY OF THE FOLLOWING REPORTS? IF YES, ATTACH COPY OR REFERENCE IN SECTION C.
a. COMMENDATORY
b. ADVERSE
c. DISCIPLINARY ACTION
YES NO
18. REPORT BASED ON OBSERVATION
DAILY
FREQUENT
INFREQUENT
19. QUALIFIED FOR PROMOTION
NOT APPLICABLE
YES
NO
20. RECOMMENDATION FOR NEXT DUTY
CONCUR WITH ITEM 10 OR RECOMMEND
1 2 3 A B C
21. RESERVED FOR FUTURE USE
CONSIDER THE MARINE REPORTED ON IN COMPARISON WITH ALL OTHERS WHOSE PROFESSIONAL ABILITIES ARE KNOWN TO YOU PERSONALLY

SECTION - C

SECTION C. REPORTING SENIOR COMPLETE IN BLACK INK
RECORD A CONCISE APPRAISAL OF THE PROFESSIONAL CHARACTER OF MARINE REPORTED ON. THIS SPACE MUST NOT BE LEFT BLANK.
SAMPLE

Figure 1: USMC Fitness Report (Extract)

II. PROBLEM STATEMENT

Several problems exist within the Marine Corps performance evaluation system. For example, a reporting senior is responsible for the job performance of his subordinates and will often inflate a superior performer's markings in areas which are not job-related because of a natural reluctance to risk demotivating a valued performer [Ref. 2]. In these cases, counseling sessions often fail to be corrective and thus deprive the individual of an opportunity to improve in addition to inflating the overall reporting system.

Another problem is that some reporting seniors deliberately inflate reports because they feel the "system" is already inflated and they do not want to hurt a valued subordinate's career chances. The effect of inflated markings is that fitness reports become less effective as tools helping selection boards discriminate between individuals. These problems have been studied and corrective action has been recommended; however, no effective system has been devised for monitoring the present or recommended performance evaluation system.

The fitness report is a critical portion of the performance evaluation system because of its use in the assignment and selection processes. The problem of

inflated fitness report markings is presently monitored by calculating the percentage of Marines marked "outstanding" in "Regular Duties" and comparing the result with historical data. Thus, an increase from previous percentages indicates a trend toward inflated fitness reports.

This method has three short-comings. First, an upward trend may be the result of an improvement in the quality of service personnel and not an effect of inflation. For example, in recent years the Marine Corps has been able to recruit significantly larger numbers of Marines of higher caliber. As these Marines reach reporting rank, an upward trend in markings can be expected. Secondly, percentage increases may not be significant and conceivably may be well within allowable variance. Finally, fitness report inflation is not intrinsically bad. It is only when inflation begins to interfere with a selection board's ability to discriminate between individuals that inflation becomes a problem. When this occurs the fitness report no longer effectively fulfills its function--use in the assignment and selection process.

The purpose of this thesis is to determine how well the fitness report serves its purpose and to devise a method for monitoring the performance evaluation system.

III. GENERAL APPROACH TO SOLUTION

Determining how well fitness reports fulfill their function is tantamount to determining the use and weight attached to fitness reports by promotion boards. Obviously, if little use is made of them, fitness reports do not fulfill their purpose and promotion decisions must be made with other information.

The general approach used to determine fitness report usefulness is model the "decision to promote" as a linear function of variables constructed from quantifiable fitness report information. The model's degree of success in explaining promotion decisions will be directly related to the usefulness of fitness reports to promotion boards.

The performance evaluation system can be monitored by comparing how well the model functions in one year with its performance during preceding years. For example, the problem of inflationary pressure should make fitness reports less useful to successive promotion boards while decreasing the ability of the model to correctly explain promotion board results. Additionally, the model can be used to answer questions about the importance of early fitness reports, to predict promotion, and to identify individuals who may warrant futher consideration by a promotion board.

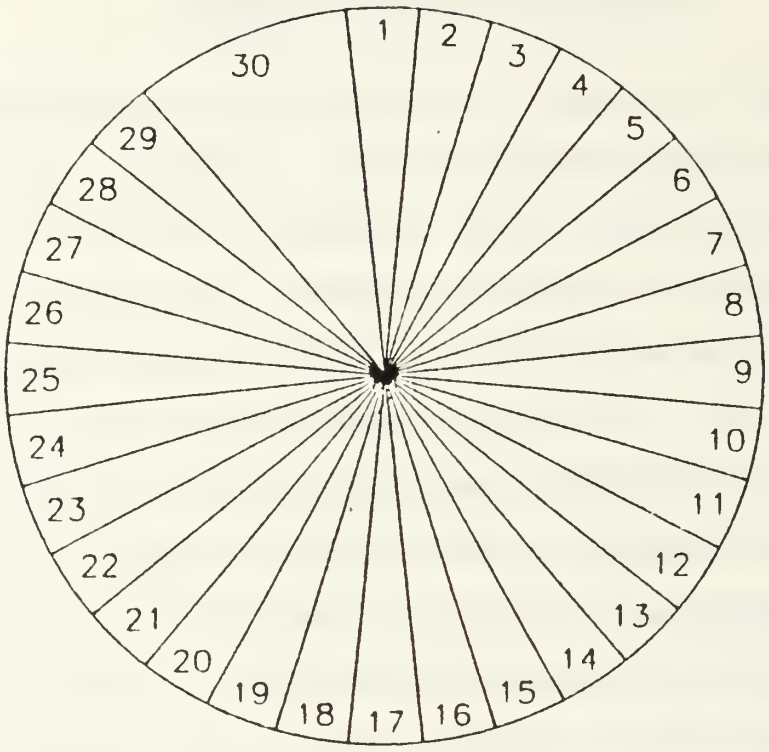
IV. ANALYTIC MODEL

Figure 2 portrays conceptually the decision to select a Marine for promotion. Each segment of the circle represents a particular category of information available to an arbitrary promotion board. The first 28 segments represent the quantifiable information categories found in section B of the fitness report. Segment 29 represents the rank of the reporting senior who wrote the report. Segment 30 represents all non-quantifiable "other" information a board possesses about an eligible Marine such as Section C comments and professional reputation.

If the size of each segment from Figure 2 is shown proportional to the weight each category of information possesses in the decision to promote, then Figure 2 represents the usefulness of fitness report information relative to "other" information. A large aggregate of fitness report segments in relation to the "other" segment means that fitness reports are useful. A small aggregate means that fitness reports are not serving their purpose as the primary tool in the selection process.

A. GENERAL MODEL

Since the "decision to promote" is categorical (yes or no), discriminant analysis is the appropriate statistical



1. Regular duties
2. Additional Duties
3. Administrative Duties
4. Handling Officers
5. Handling Enlisted
6. Training Personnel
7. Tactical Handling/Troops
8. Endurance
9. Personal Relation
10. Military Presence
11. Attention to duty
12. Cooperation
13. Initiative
14. Judgement
15. Presence of Mind
16. Force
17. Leadership
18. Loyalty
19. Personal Relations
20. Economy/Management
21. Growth Potential
22. General Value....
23. Distribution of....
24. Item 16
25. Commendatory
26. Adverse
27. Disciplinary
28. Qual. for Promotion
29. Rept. Senior Grade
30. Other

Figure 2: Decision To Promote

method for use in model developement. Discriminant analysis is a technique which derives the linear combination of two or more independent variables which best discriminate among the values of a nominally scaled dependent variable. A general mathematical model describing the decision to promote is:

$$Z = w_1X_1 + w_2X_2 + \ldots + w_{30}X_{30} \qquad (1)$$

where Z is initially a categorical, dependent variable taking on the values of "1" or "0" for each observation and representing the decision made to promote an individual if "1" or not to promote if "0". X_1 through X_{29} are independent variables representing 29 available, quantifiable information categories. X_{30} represents any "other" information a promotion board possesses about an individual that affects the promotion decision. The coefficients w_1 through w_{30} represent the weight each independent variable (information category) possesses for a particular board's decision.

B. ASSUMPTIONS

There are three assumptions underlying the model given by Equation 1:

1. Multivariate normality for independent variable distribution.
2. Unknown but equal dispersion and covariance structures for the dependent variable groups--"yes or no".
3. There is no exact linear relationship between the independent variables.

Violation of the third assumption will produce coefficients which are ambiguous in meaning as weights. For example, small weights may mean that the corresponding variables are either irrelevant or that they have been partialled out of the relationship because of a high degree of multicollinearity [Ref. 3].

A study of fitness report data on sergeants, gunnery sergeants, lieutenants and majors was conducted by Texas A&M [Ref. 4] in order to determine if the number of fitness report dimensions (information categories) might be reduced and whether or not the same fitness report form was suitable for all rank structures. The study found existence of strong positive intercorrelations among many of the independent variables, indicating that multicollinearity exists among many fitness report marking categories. For example, the study found that markings for "Military Presence" and "Personal Appearance" are strongly related,

> "because they tap a single construct in the rater's mind--some idea of correct military bearing. In giving ratings, raters tended to give a person similar scores for these two variables--both high, or both low."

The Texas A & M study analyzed 16 of the first 22 fitness report markings and discovered intercorrelations strong enough to form four distinct groups of markings. (Weak intercorrelations would have resulted in a larger number of groups.) To a high degree these group relationships were found to exist across all rank structures and their study

supports the creation of composite variables in a model describing the decision to promote. Use of composites of related variables will reduce multicollinear effects and make the third assumption more justifiable. Further analysis and discussion of the referenced study are presented in Appendix B.

C. FACTOR ANALYSIS AND COMPOSITE VARIABLES

Factor analysis was the method used to identify variable groupings from which composite variables were constructed. This analytic method consists of analyzing the interrelationships among a number of variables and then explaining the variables in terms of their common dimensions or factors [Ref. 2: p. 218]. Unlike regression analysis in which one variable is considered dependent and all others are considered independent explanatory variables, factor analysis is an interdependence technique in which all variables are considered a dependent variable that is a linear function of a set of mathematically defined common factors. The coefficients of this linear model are termed "loadings". Again by comparison, the factors of factor analysis are the independent variables of the regression analysis while the loadings are the coefficients of the regression model [Ref. 4]. In factor analysis the questions answered are:

1. What is the smallest number of linear dimensions (factors) which can be used to describe a vector space spanned by a set of dependent variables?

2. Which dependent variables can be used to define each dimension?

In terms of fitness report data, factor analysis answers the following questions:

1. What is the smallest number or groups of marking categories that can be used to adequately profile an individual who is described by a set of fitness report markings?

2. Which marking categories can be used to form each group?

Factor analysis is sometimes criticized [Ref. 5: pp. 17-19]. One criticism results from the arbitrariness associated with the rotation method used to produce the factors. In this study, six methods of rotation were employed with consistent results for all rotation methods. A second criticism is that the data must have an underlying multivariate normal distribution measured on at least an interval scale. Although certain categories of data analyzed in this study are initially discrete and probably only ordinally scaled, observations were treated as interval scale data and values within the categories were averaged prior to factoring and thus converted more nearly to a continuous scale. Additional comments about the scale of measurement are found in Chapter VIII.

1. Factor Analysis

A factor analysis was performed on the fitness report data used by the 1984 promotion board to Major [See Appendix A]. Principal component analysis with varimax rotation of all factors greater than one was employed. All fitness report marking categories were included except for "endurance", "tactical handling of troops", and "presence of mind" which were excluded due to lack of data. Items

TABLE 1: FACTOR LOADINGS - 1984 MAJOR'S DATA BASE

FACTOR	ITEM	LOADINGS
1	Handling Enlisted	.76
	Leadership	.68
	Force	.55
	Training Personnel	.50
	Handling Officers	.54
2	Attention to Duty	.72
	Initiative	.71
	Commendation	.47
3	Cooperation	.84
	Loyalty	.54
	Personal Relations	.81
4	Personal Appearance	.86
	Military Presence	.83
5	Judgement	.54
	Economy of Management	.59
	Administrative Duties	.73
	Qualified for Promotion	.45
	Regular Duties	.52
	Growth	.56
	Item 16	.41
7	Disciplinary	.75
	Adverse	.74
8	Truth-Teller	.81

15a and 15b were replaced with the "truth-teller" discussed in Appendix A. Eight factors emerged and are

presented in Table 1. These factors were used to form composite variables.

2. Composite Variables

The first seven factors identified in Table 1 were used to structure seven composite variables for inclusion in the model describing the decision to promote. Factor loadings range between -1.0 and +1.0 and represent the correlation between an item and a factor. Factor loadings above .3 or .4 are generally considered significant [Ref.4: p. 6]. In this study, factor loadings above .40 were required for composite variable selection.

"Tactical handling of troops", "endurance", and "presence of mind" are related to each other by a characteristic clearly distinct from all other categories --each is normally only evaluated for actual combat duty. This strong and distinct relationship justifies the formation of an eighth composite variable for inclusion in the model. The eight composite variables are listed in Table 2.

An observation for each composite variable was computed by averaging the means of all subordinate, related variables. Each assumed values between "0" and "9". The averaging of means insured that each related variable possessed the same weight in forming observations for the associated composite variable. This removed uncertain

weighting effects caused by unequal numbers of observations for each related variable at the cost of equal weighting.

TABLE 2: COMPOSITE VARIABLES

X1	X2
Handling Enlisted	Attention to Duty
Leadership	Initiative
Force	Commendatory
Training Personnel	
Handling Officers	
X3	**X4**
Cooperation	Personnel Appearance
Loyalty	Military Presence
Personnel Relations	
X5	**X6**
Judgement	Regular Duties
Economy of Management	Growth
Administrative Duties	Item 16
Qualified for Promotion	
X7	**X8**
Disciplinary	Tac_Handling/Troops
Adverse	Endurance
	Presence of Mind

D. MODEL CONSTRUCTION

In order to reduce multicollinearity and make the third model assumption more justifiable, the "decision to promote" was first modeled as a function of the composite variables discussed above. The model takes the form:

$$Z = w_1X_1 + w_2X_2 + w_3X_3 + \ldots + w_{11}X_{11} \qquad (2)$$

where X_1 through X_8 are explanatory variables which assume values between "0" and "9" representing the average value of each of the eight groups of correlated fitness report markings identified in Table 2.

"Additional Duties (Item 13b) and the "truth-teller" were found to be unrelated to any other category and form the ninth and tenth variables in the model. A discussion of these variables and their transformation is presented in Appendix A.

One additional variable can be constructed from fitness report information for addition to the model. The variable is defined as "reporting senior grade" and represents the average rank of all officers submitting fitness reports on a particular individual. This variable is added to the model for two reasons. First, a Marine whose reporting senior is a high-ranking officer will generally possess a highly visible assignment. A promotion board member is therefore more likely to have personal knowledge about the Marine. This knowledge can be expected to affect promotion decisions. Secondly, it may well be that promotion boards give more weight to reports written by higher ranking officers. This will also affect promotion decisions. Observations for this variable were created by first assigning numerical values to each rank: a "1" for a second lieutenant, a "2" for a first lieutenant, a "3" for a captain and so forth. Numerical values were then averaged to create observations which were continuous between "1" and "9". "Reporting senior grade" was added to the model as X_{11}.

V. ANALYTIC RESULTS

The general form of the discriminate analytic model was discussed in Chapter IV of this paper and was presented in mathematical form as Equation 1. After factor analysis and the formation of composite variables discussed in Chapter IV.C, the model was reduced dimensionally to the form given by Equation 2 which is repeated below for ease of reference.

$$Z = w_1X_1 + w_2X_2 + w_3X_3 + \ldots + w_{11}X_{11} \qquad (3)$$

where

Z = discriminant score
W_i = discriminant weights
X_i = explanatory variables

As previously discussed, discriminant analysis involves the derivation of the linear combinations of two or more explanatory variables which best discriminate among the values of a nominally scaled dependent variable. Equation 3 shows that each explanatory variable is multiplied by its discriminant weight. These products are then summed to form a discriminant score representing each individual Marine's fitness report profile. Discriminant scores are then sorted into two groups according to those selected and those not selected for promotion. Group means are then calculated which represent the most likely discriminant score for an individual within each class. The interval between group

means represents how much the groups are separated along the dimension (explanatory variable) being tested. A small interval indicates that the model does not discriminate well between groups. A large interval indicates good separation and that good classification results are likely.

The hypothesis that the group means are equal is then tested. If this hypothesis is rejected, individuals are classified into groups according to proximity of individual discriminant scores to group means. Proximity is defined as the smallest generalized squared distance of a discriminant score to a group mean [Ref.6]. If the model classifies all or most of the individuals into the correct groups of selected Marines and non-selected Marines, two conclusions are evident: the model adequately describes the decision process and the data base is sufficient to explain decisions.

Discriminant analysis was used to study one data set containing all fitness report information available to one promotion board. Each data set was transformed as described in Appendix A and the 11 explanatory variables discussed in Chapter IV.D. were used to classify Marines into the two selection categories. The model was solved with a statistical analysis program copyrighted by the SAS Institute for use on an IBM 3033 mainframe computer.

The SAS Institute discriminate analytic procedure uses the pooled covariance matrix to develop classification criterion taking into account the prior proportional probability (binomial) for group membership. The procedure then uses this classification criterion to classify individual observations into one of the two groups. Optionally, the data can be divided into two parts with classification criterion developed from one part for use in classifying the second portion of data. Several different types of outputs listings are available to users; however, for this paper two listings were sufficient for analysis: a classification summary of observations, and a summary of simple statistics such as mean and variance.

A. 1984 MAJOR'S PROMOTION BOARD DATA

After transformation, the 1984 major's promotion board data consisted of observed fitness report information profiling 717 Marines. 59 of these profiles were not complete and were excluded from analysis. Analysis was conducted on the remaining 658 observations.

1. Fitness Report Usefulness

The usefulness of fitness report data to this promotion board was first studied. Discriminant analysis was used to solve the model for the 658 observations in the data base. Classification results are shown below as a percentage and number of Marines correctly classified into

the two groups of those selected for promotion (SELECTS) and those not selected for promotion (NON-SELECTS):

	Percent Classified Correctly	Number Classified Correctly	Number Not Classified Correctly
SELECTS	90.17	373	41
NON-SELECTS	72.54	177	67

The wide disparity between correct classification percentages seems to argue that the model does not work well. Discussion with Marines experienced with promotion boards indicated that a possible explanation might be that two distinctly different decisions are made by most promotion boards. Apparently, one criteria is used to select those Marines very obviously best qualified for promotion and a different set of criteria is used to choose those Marines qualifying for non-selection. Thus, two decisions are made from the same data base. If correct, our model which attempts to explain the board's decisions using a single criterion needs modification.

To test this hypothesis, the data were first sorted by promotion zone. This divided the data into two parts representing those Marines who had previously been passed over for promotion (above-zone) and those Marines being considered for promotion for the first time (in-zone). This particular division was selected because above-zone Marines were more likely as a group to meet non-selection criteria (having done so previously) and thus variance associated with a dual decision model could be

reduced. Assuming that the two-decision model was correct, it was expected that the performance of the model would be improved when classifying SELECTS from the in-zone category and NON-SELECTS from above-zone. It was also expected that the model's performance would decrease when the model is used to classify NON-SELECTS from the in-zone category and SELECTS from above-zone.

Discriminant analysis was repeated for each data group with the following results:

	Percent Classified Correctly	Number Classified Correctly	Number Not Classified Correctly
Above-zone			
SELECTS	45.83	22	26
NON-SELECTS	92.98	106	8
In-zone			
SELECTS	95.64	351	16
NON-SELECTS	64.64	84	46

The expected results were achieved. The above-zone percentage of correctly classified NON-SELECTS increased from 72.54% to 92.98% while correctly classified SELECTS decreased from 90.17% to 45.83%. The in-zone percentage of correctly classified SELECTS increased to 95.64% while NON-SELECTS decreased to 64.64%. Whether or not the two-decision theory is justified, these results indicate that fitness report information was sufficient to enable this promotion board to discriminate between individuals considered for promotion. The high percentages of correctly classified above-zone NON-SELECTS and in-zone SELECTS simply could not have been achieved unless the promotion

decision (or decisions) were made primarily with fitness report data. It can safely be assumed that fitness reports were extremely useful to this promotion board.

2. Inflation

It is conceivable that inflated fitness report markings have made recent reports less useful to selection boards. If this has happened and if the promotion boards base their decisions primarily on fitness report data, older fitness reports must be more useful to promotion boards than more recent reports. To test this, older fitness reports can be removed from the data, analysis repeated, and results compared with previous results achieved with a complete data base sorted by zone. If older, less inflated reports are better discriminators than more recent ones, analysis should indicate a decrease in the model's ability to correctly classify results.

First, all fitness reports written on second lieutenants were deleted leaving first lieutenant and captain reports in the data base. After analysis, first lieutenant reports were also deleted and analysis was repeated with the following results:

	Percent Classified Correctly	Number Classified Correctly	Number Not Classified Correctly
Complete data base			
Above-zone NON-SELECTS	92.98	106	8
In-zone SELECTS	95.64	351	16
1stLt & Capt data base			
Above-zone NON-SELECTS	89.72	96	11
In-zone SELECTS	96.08	343	14

Captain's data base			
Above-Zone NON-SELECTS	87.21	75	11
In-zone SELECTS	96.12	248	10

As expected, the percentage of correctly classified NON-SELECTS decreased from 92.98% to 89.72% after deleting second lieutenant reports and then decreased further to 87.21% when first lieutenant data were removed. However, the percentage of correctly classified in-zone SELECTS did not decrease--remaining at about 96%. If this promotion board had been forced to rely heavily on older reports in order to make promotion decisions, correctly classified percentages would have decreased in both categories since the basis (older reports) for decision had been removed.

Clearly, inflation did not reduce the ability of the 1984 major's promotion board to make its selection decision; however, decreases in correctly classified NON-SELECTS may be the result of inflation affecting the non-selection decision. It also may be the result of deleting poor fitness reports which most likely occur early in a Marine's career.

To test this alternative explanation, the data were first sorted by zone and then sorted by military rank within zone. Analytic results were compared with the results from analysis of the complete data base sorted by zone. If junior officer reports are important to selection boards making a non-selection decision, the model should improve its performance by better classifying NON-SELECTS

using first or second lieutenant data bases. In addition, the model's ability to classify NON-SELECTS using the captain's data base should decrease since hypothetically, better discriminating junior reports have been removed:

	Percent Classified Correctly	Number Classified Correctly	Number Not Classified Correctly
Complete data base			
Above-zone NON-SELECTS	92.98	106	8
In-zone SELECTS	95.64	351	16
2ndLt data base			
Above-zone NON-SELECTS	94.74	36	2
In-zone SELECTS	95.79	91	4
1stLt data base			
Above-Zone NON-SELECTS	95.51	85	4
In-zone SELECTS	94.06	269	17
Captain's data base			
Above-zone NON-SELECTS	85.88	73	12
In-zone SELECTS	96.84	245	8

As expected, percentages of correctly classified NON-SELECTS using first and second lieutenant data bases increased from the 92.98% achieved with the complete data base and decreased considerably when the captain's data base was analyzed. Correctly classified percentages of SELECTS remained about the same. Two conclusions can be drawn from these results.

First, there is no evidence that inflation reduced the 1984 major's promotion board's ability to make its promotion decisions because an improvement in the model's ability to discriminate in both categories was expected when the older reports were used but did not occur. Second, although first and second lieutenant reports did not add

appreciably to the model's ability to explain the board's selection decision, they do seem important in explaining decisions not to promote. In other words, first and second lieutenant reports did not necessarily get a Marine promoted to major; however, they probably were important in his being passed over for promotion a second time. The two-decision hypothesis works well to explain these results.

VI. MODEL VALIDATION BY PREDICTION

The two-decision model developed in this paper can be validated by showing that the model can be used to predict promotion in addition to discriminating between individuals already selected for promotion. This can be accomplished by dividing the data randomly into two halves, computing discriminant weights using one half of the data, and then using these weights to compute discriminant scores with which to classify the other half of the data. The model will be validated if classification results approximate those achieved using the first half of the data.

A. VALIDATION

Validation was accomplished using the 1984 major's promotion board data. After sorting the data by social security number, the data were divided roughly into two

halves--a calibration data set and a test data set. Both data sets were then sorted by promotion zone and discriminant analysis was applied to the calibration data set using the two-decision model. Classification results were:

	Percent Classified Correctly	Number Classified Correctly	Number Not Classified Correctly
Calibration data set			
Above-zone NON-SELECTS	83.33	45	9
In-zone SELECTS	96.46	191	7
Complete data base			
Above-zone NON-SELECTS	92.98	106	8
In-zone SELECTS	96.12	248	10

Relative to the 92.98% achieved with the complete data base, a relatively small percentage of correctly classified NON-SELECTS was achieved using the calibration data set. This was probably the result of having too few observations available to make the multivariate normal assumption completely valid. The discriminant weights and classification criteria developed using the calibration data were then applied to the test data set with the following results:

	Percent Classified Correctly	Number Classified Correctly	Number Not Classified Correctly
Calibration data set			
Above-zone NON-SELECTS	83.33	45	9
In-zone SELECTS	96.46	191	7
Test data set			
Above-zone NON-SELECTS	81.67	49	11
In-zone SELECTS	93.45	157	11

Although small decreases in the model's ability to discriminate were observed, the differences are statistically insignificant. Consequently, the two-decision model is supported by the validation study.

B. PREDICTING PROMOTION

Validation indicated that the model also can be used to predict promotion. A predictive model has a variety of uses. For example, consider the classification results achieved using a data base consisting of second lieutenant fitness report data from the 1984 major's promotion board data set:

	Percent Classified Correctly	Number Classified Correctly	Number Not Classified Correctly
2ndLt data base			
Above-zone NON-SELECTS	94.74	36	2
In-zone SELECTS	95.79	91	4

The discriminant weights and classification criteria developed using this data base may be applied to a current second lieutenant data set in order to predict attrition by promotion pass-over eight years from now. Predictive results (adjusted for inflation) may well approach those shown above if sufficient numbers of observations can be obtained. This could be useful to manpower planners who need plenty of lead time to ensure sufficient numbers of properly trained majors in particular occupational fields. Discriminant scores could be used as an additional explanatory variable in existing general attrition models.

Since the discriminant scores are normally distributed (with parameters which can be estimated), a probability for promotion and a confidence interval can be established for each prediction.

Another use for a predictive model might be to use one year's decision criteria to establish the promotion zone size for the following year. This could help prevent unnecessary promotion passover due to unexpected selections that may be made from above zone.

VII. MONITORING THE PERFORMANCE EVALUATION SYSTEM

In order to monitor the fitness report aspects of the performance evaluation system, an unambiguous measure is needed that responds to the factors affecting the promotion decision in a consistent manner. This measure, which we call the System Index, generally has meaning only when compared to other similar indices. The System Index will be constructed from another index representing the discriminating success of the two-decision model. This second index is called the model Performance Index. The two indices will differ depending on which factors affect the promotion decision. The general approach to formulation of the System Index consists of three steps:

1. Develop a performance index which represents the discriminating results of the two-decision model.

2. Study the factors which affect promotion decisions and their effects on the model Performance Index.

3. Develop a System Index by modifying the model Performance Index to respond in a predictable way to factors affecting promotion decisions.

A. MODEL PERFORMANCE INDEX

A composite view of model performance can be achieved by calculating a weighted fraction from the number of individuals correctly classified. There are two sets of classification results generated by the two-decision model --one set for each promotion zone. The fraction of correctly classified individuals is given by:

$$W = \frac{AN+AS+IN+IS}{A + I} \qquad (4)$$

where

AS = No. of correctly classifies above-zone SELECTS
AN = No. of correctly classifies above-zone NON-SELECTS
IS = No. of correctly classified in-zone SELECTS
IN = No. of correctly classified in-zone NON-SELECTS
A = Total No. above-zone considered by the model
I = Total No. in-zone considered by the model

Unfortunately, this does not take into account the prior probability of correct classification due to chance. For example, a fraction of .96 may seem to indicate good results. However, if the a priori probability of correct classification (weighted fraction of eligible Marines actually promoted) were ,say, .95, the model would have achieved results little better than the expected results achievable from random chance. Considered alone, the weighted fraction may be misleading.

In order to avoid this problem, a reference level is needed from which to measure results. Hair [Ref. 3:p. 102] recommends using the chance probability for correct classification as a comparison. This measure, called the proportional chance criterion, can be computed by Equation (5):

$$CP = p^2 + (1-p)^2 \qquad (5)$$

where

CP = Proportional chance criterion
p = fraction of NON-SELECTS in the total population
1-p = fraction of SELECTS in the total population

A simple model performance index can be created by dividing the weighted fraction by the proportional chance criterion; i.e.:

$$\text{Performance Index: (PI)} = W/CP \qquad (7)$$

The Performance Index will take on values between zero and two. A performance index of one means that the two-decision model achieved classification results about as good as a random selection model. An index of 1.5 means that the model was 50% better; and so forth.

B. FACTORS AFFECTING THE PROMOTION DECISION AND THE MODEL PERFORMANCE INDEX

There are three factors which will affect the promotion decision and/or the results of the two-decision model. One of these factors will affect the model's ability to predict promotion without affecting the Performance Index. The other two factors will affect both.

1. Membership Factor

Since promotion board membership varies from year to year, it is conceivable that promotion decisions over time might be made with differing decision criteria. Significant differences between boards can be detected by observing reduction in the model's ability to predict one year's results using decision criteria generated from a previous year. Although predictive capability may decrease somewhat, the model Performance Index should not change as long as the fitness report remains the primary information source for decision making.

2. Combat Factor

A particular promotion board may choose NOT to base decisions primarily on fitness report data even though fitness report information may have potential for use. For example, combat experience and citations for bravery may influence a board as much as fitness report profiles. There will be two effects on the model if an unusual number of officers with these qualifications, but without the best fitness report records, are selected by a particular promotion board. The model's ability to predict this promotion board outcome using previous year decision criteria will be reduced and the model Performance Index will decrease. These effects will occur because the model does not possess some of the information that this board considered important.

A decreasing trend in model Performance Index over several promotion boards may indicate that other factors such as the "combat" factor are gaining importance in promotion decisions. For example, advanced degrees and attendance of high-level military schools may gain more importance to promotion boards during peacetime. Since this information is not explicitly included in Section B of the fitness report, the model Performance Index will display a declining trend. This may indicate that the model needs adjustment or that the fitness report needs updating to include newly obtained important information. A decreasing trend may also be due to the effects of inflation.

3. Inflation Factor

By making fitness reports less useful to promotion boards, inflation in fitness report markings may force boards to make decisions based on information not available to the model. If this happens, one effect will be to decrease the ability of the model to predict current year results using decision criteria generated from previous year data. Fitness report inflation will generally affect model prediction ability since the discriminant scores generated from the less inflated data may be too low to classify the more inflated data with much success.

This thesis considers three scenarios for inflation. Variance is assumed to remain constant in two

cases and decreases for the third. The three cases are illustrated by Figures 3, 4, and 5.

a. Case 1

The first case assumes that there is no end-point effect. In Figure 3, "S" represents the mean

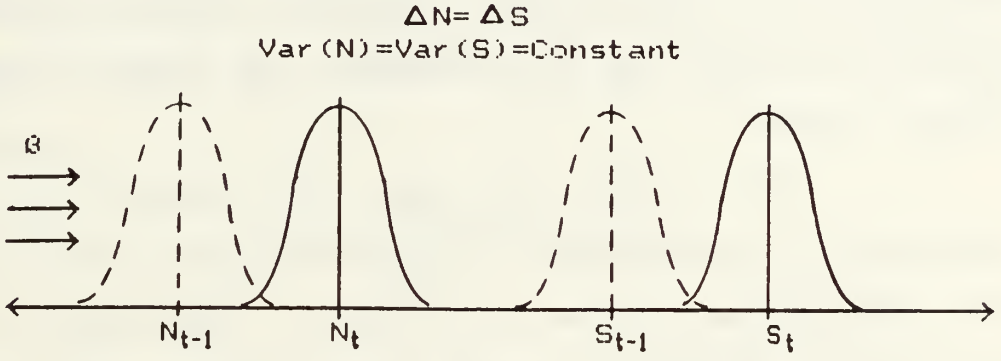


Figure 3: Case-1 Inflation

discriminant score for the population consisting of all individuals who were selected for promotion. "N" represents an equivalent value for individuals not selected. Both populations are assumed to move to the right by the same amount under the effect of inflation. There is no change in variance associated with either movement.

Fitness report inflation of this type may be described by:

$$S_t = S_{t-1} + C$$
$$N_t = N_{t-1} + C$$

where "S" and "N" are the population means at time "t" and "C" is some constant related to the inflationary pressure ß. The constant "C" represents the distance both populations move to the right in one unit of time.

If the populations move at the same speed, there will be no change in the difference between the means of the two populations. Discriminant analytic results depend on the distances between the means and on the variances of the two populations--both of which are constant for this case of inflation. Since discriminant analytic results will not change, the model PI will not change either.

In order to test the effects of Case-1 inflation on the model PI, an arbitrary value for "C" of .3 was added to each variable for every observation of the 1984 major's promotion data. The two-decision model was then used to classify the adjusted data. As expected, classification results were identical to those achieved with the original data and indicated that the model PI will not be affected by Case-1 inflation.

As previously discussed, the predictive ability of the model using the previous year's decision criteria will decrease. However, if inflation exhibits this type of behavior an adjustment can be made to the earlier data which will improve predictive results. This adjustment consists of adding the difference in means between the previous year's data and the current year's data to the previous data. The adjusted data (inflated to current year levels) is then used to establish decision criteria to classify the current data. By adjusting for a difference in

means, predictive results using previous year decision criteria should increase toward the level achievable if inflation had not been present.

b. Case 2

Figure 4 shows the second type of inflation in which the variances of the two populations do not change but in which the means are translated to the right by different distances.

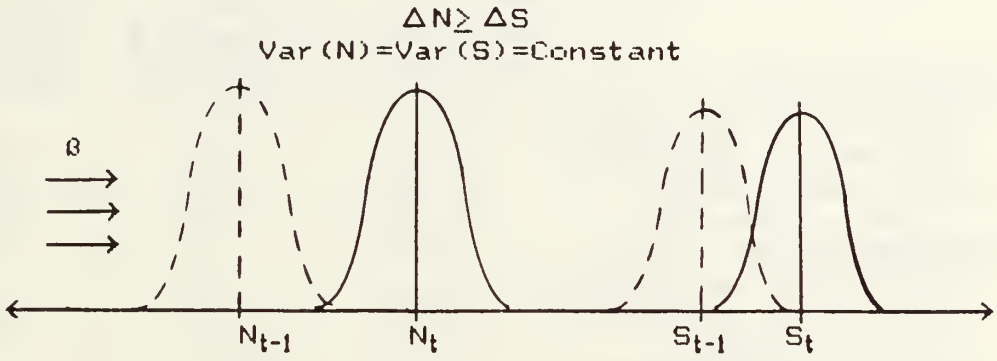


Figure 4: Case-2 Inflation

The population of NON-SELECTS is shown overtaking the population of SELECTS and thus is assumed to be more affected by inflationary pressure. Case-2 inflation is described by the model:

$$S_t = S_{t-1} + C_s$$
$$N_t = N_{t-1} + C_n$$

where C_s and C_n are constants. C_s represents the distance that the population of SELECTS moves to the right during one unit of time; and C_n is an equivalent term for the NON-SELECTS. For this case, we assume that $0 \leq C_s < C_n$ and $C_n \leq (S_{t-1} - N_{t-1})$. If inflation behaves in this fashion, the

model PI will decrease since the difference between the two mean values decreases with no accompanying change in variances.

This was tested using the 1984 major's data. Arbitrary values for C_n and C_s (.4 and .1, respectively) were added to each observation of the appropriate population. The observations were then classified by the two-decision model with the following results:

	Percent Correctly Classified	Number Correctly Classified	Number Not Correctly Classified
Original Data			
Above-zone NON-SELECTS	92.98	106	8
Above-zone SELECTS	45.83	22	26
In-zone SELECTS	95.64	351	16
In-zone NON-SELECTS	64.64	84	46
Inflated Data			
Above-zone NON-SELECTS	100.00	114	0
Above-zone SELECTS	2.08	1	47
In-zone SELECTS	99.45	364	2
In-zone NON-SELECTS	5.38	7	123

Classification results were clearly different. The model PI was calculated and (as expected) was found to decrease from 1.620 for the original data to 1.397 for the inflated data.

The ability of the model to predict promotion will decrease for the same reason. Data adjustment will not improve prediction because the adjusted data experiences the same decrease in the distance between the means. This type of inflation will affect promotion decisions because the fitness report profiles for individuals in both groups will become less distinguishable.

c. Case 3

The classical model for inflation is:

$$X_t = (1+\beta) * X_{t-1}$$
$$Y_t = (1+\beta) * Y_{t-1}$$

where "X" and "Y" are the means of two distributions at time "t" and β is an inflationary pressure such that $0 \leq \beta$. The difference between means is calculated by:

$$X_t - Y_t = (1+\beta) * (X_{t-1} - Y_{t-1})$$

and increases linearly at a rate equal to $(1+\beta)$. The variances for the population means are:

$$Var(X_t) = (1+\beta)^2 * Var(X_{t-1})$$
$$Var(Y_t) = (1+\beta)^2 * Var(Y_{t-1})$$

and increase with the square of the $(1+\beta)$ term. Since β does not possess an upper bound the population means will separate continuously and variances will increase at a faster rate than separation. If fitness report inflation behaves in this manner the model PI will decrease with time because good discrimination requires small variances relative to the degree of separation.

Unfortunately, fitness report inflation possesses an upper bound and cannot be modeled accurately by such a one-parameter model. This upper bound is the logical end-point where all officers are rated outstanding in all categories. End-point effects have never been fully studied; however, individuals experienced with school grade inflation have been able to offer some clues about its nature.

Their experiences indicate that the number of individuals reaching the logical grade end-point of an "A" has increased at a much lower rate than the number of individuals reaching the "B" level. Hence, the average grade assigned has increased under inflationary pressure but at a decreasing rate. At schools where the average grade has stabilized, inflation is said to be stopped or at least to be under control. In these situations, the inflated school grade distribution possesses a mean value less than the logical end-point and has a variance somewhat smaller than its noninflated distribution. A heuristic model for the effects of inflation on school grades is given by:

$$G_t = G_{t-1} + (\beta)*(E-G_{t-1}) \qquad (8)$$

where G_t is an average grade at time "t"; β represents an inflationary pressure tending to increase scores; and "E" is the logical end-point. Thus, the observed effects of inflation are larger for a distribution whose values are more distant from its end point than for a distribution with values closer to the end point. In Equation (8), either β or "E" must be treated as a function of G_{t-1} since school grade inflation seems to stabilize at some point less than the logical end-point. We chose to consider β as a variable because it was easier to work with. Therefore, in our model β possesses a positive value less than one and decreases to zero when grades stabilize. Since each

observation of the distribution approaches the logical end-point until stopping (when ß=0), the variance will also decrease. To show this, the variance is calculated by:

$$Var(G_t) = (1-ß)2 * Var(G_{t-1})$$

which indicates that variance will always decrease with the square of the (1-ß) term when there are end-point effects.

Assuming that fitness report inflation is similar to school grade inflation, Equation (8) offers a reasonable model for studying the end-point effects on the model PI. Figure 5 illustrates this third type of inflationary

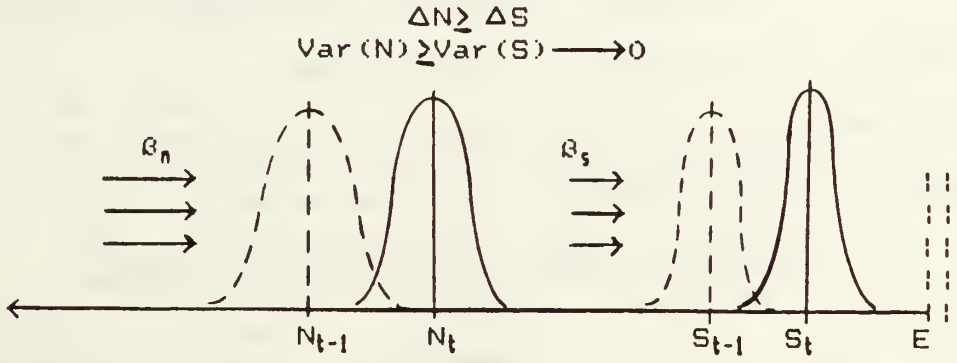


Figure 5: Case-3 Inflation

behavior in which a growing end-point effect slows both population movements. As the two population means approach the end-point, variances become smaller. This type of behavior was modeled from Equation (8):

$$S_t = S_{t-1} + ß_s*(E-S_{t-1}) \qquad (9)$$
$$N_t = N_{t-1} + ß_n*(E-N_{t-1}) \qquad (10)$$

where:

S,N = the population means at a given time t
E = logical end-point
$ß_s, ß_n$ = inflationary pressure : $0 \leq ß \leq 1$ for each population

in these equations, the terms β_s and β_n represent the net pressures that determine, along with the distances from the end-point, how far each population moves during one unit of time. If these terms reach zero before the population means reach the logical end-point, stabilization will occur. No more movement to the right will be possible and the variance associated with each population will also stabilize.

If inflation behaves in this manner, the model PI may actually increase even though promotion boards may be unable to distinguish between individual fitness report records. The reason this could happen is that the variance associated with each distribution may become so small as the population means stabilize that the model has no difficulty

TABLE 3: CASE-3 INFLATION TEST RESULTS

	Percent Classified Correctly	Number Classified Correctly	Number Not Classified Correctly
Original Data			
Above-zone NON-SELECTS	92.98	106	8
Above-zone SELECTS	45.83	22	26
In-zone SELECTS	95.64	351	16
In-zone NON-SELECTS	64.64	84	46
Inflated Data			
Above-zone NON-SELECTS	100.00	114	0
Above-zone SELECTS	95.83	46	2
In-zone SELECTS	96.99	355	11
In-zone NON-SELECTS	100.00	130	0

discriminating regardless of how small the actual difference between population means.

To test this, β_n and β_s were arbitrarily assigned values of .95 and .90, respectively, and the 1984 major's data were inflated according to Equations (9) and (10). Classification results are shown in Table 3. The model PI was calculated and (contrary to our desires) was found to increase from 1.621 for the original data to 1.838 for the inflated data. This potential for inconsistent behavior by the model PI responding to the effects of the inflation end-point prevents the use of the PI as a System Index for monitoring the performance evaluation system.

C. SYSTEM INDEX

An index designed to monitor the performance evaluation system must be sensitive to the factors that affect promotion decisions. Furthermore, it must be sensitive only when these factors represent a problem. For example, changes in promotion board membership are not a problem but they will affect promotion decisions. An index responding to this factor would erroneously indicate a problem. Finally, the response itself must be consistent and predictable.

Although the model PI may be too inconsistent for use as a performance evaluation system monitor, our study of its response to factors affecting the promotion system showed that it possessed almost all of the other traits

needed by such a monitor. The model PI was not sensitive to board membership or Case-1 inflation (which are not problems). Similarly, it was responsive to "combat factors" and Case-2 inflation. Unfortunately, its response to the the type of inflation examined as Case-3 is neither predictable nor consistent. Although the model PI fails to respond in a desirable manner for Case-3 inflation, it is, however, possible to modify the index to force the desired response for this case without affecting its response to other factors.

The model PI fails under Case-3 inflation because the variance associated with each distribution becomes very small as population movement slows or stabilizes in response to the effect of the logical end-point. Since decreasing variance and slower movement to the right are associated with this type of inflation, each suggests a way to modify the model PI in order to make it behave as desired. The first possible way this might be done is to multiply the model PI by a factor related to the decrease in variance. However, there is no certainty that variance will decrease (only that it is likely). The second possibility is to multiply the model PI by a factor related to slower population movement. Whether or not our model for inflation is valid, the one near certainty available to us is that inflation rates will decrease as the population

approaches some limiting value. For this reason, the model PI was modified using a factor related to movement.

This factor was developed using the Case-3 inflation model presented as Equations (9) and (10) and rearranged below:

$$S_t - S_{t-1} = \beta_s * (E - S_{t-1}) \qquad (11)$$
$$N_t - N_{t-1} = \beta_n * (E - N_{t-1}) \qquad (12)$$

Assuming that results and data from two promotion boards are available, the only unknown terms in Equations (11) and (12) are β_s and β_n. These terms represent the net inflationary pressures causing the populations to move to the right in Figure 5.

Equations (11) and (12) can be used to modify the model PI and obtain a System Index with the needed characteristics. The suggested System Index is:

$$SI = PI * \frac{(S_t - S_{t-1})}{(N_t - N_{t-1})} \qquad (13)$$

The weighting factor for PI is called the forcing ratio because it forces the System Index to decrease under the effects of Case-2 or Case-3 inflation. Its numerator represents the net distance the population of SELECTS moves to the right and its denominator is an equivalent term for the population of NON-SELECTS. The forcing ratio will possess values between zero and one depending on the type of inflation.

For Case-1 inflation to occur, the two populations must move to the right at the same speed. Thus,

$$S_t - S_{t-1} = N_t - N_{t-1}$$

and

$$\frac{(S_t - S_{t-1})}{(N_t - N_{t-1})} = 1$$

A forcing value ratio of one means that Case-1 inflation is occuring. Since this type of inflation is not a problem the System Index should not and will not respond.

In order for Case-2 (or Case-3) inflation to occur, the population of NON-SELECTS must inflate faster than the population of SELECTS. For this to happen:

$$S_t - S_{t-1} < N_t - N_{t-1}$$

and

$$\frac{(S_t - S_{t-1})}{(N_t - N_{t-1})} < 1$$

The numerator in the forcing ratio will be smaller than the denominator. Thus, the forcing ratio will be a fraction that decreases the System Index and signals a problem.

In order for the third type of inflation to occur, the two populations must approach their logical end-points. Since movements are very slow, the net inflationary pressures will approach zero. The numerator of the forcing ratio will reach zero faster than the denominator because the population of SELECTS is always closer to the logical end-point than the population of NON-SELECTS and therefore it will experience stronger end-point effects and move more slowly. The forcing ratio will again be a fractional value that decreases the System Index and signals a problem.

The System Index defined by Equation (13) maintains all of the desirable characteristics of the model PI since it differs only when the forcing ratio has a value less than one. Furthermore, the forcing ratio will have a value less than one only for the types of inflation that are a problem. In spite of these favorable characteristics, it is conceivable that the System Index may still fail to indicate Case-3 inflation. This could happen if the forcing ratio fails to decrease at a greater rate than the corresponding increase of the model PI. Thus, the System Index would increase in magnitude and fail to indicate a problem. Fortunately, this condition for System Index failure can be detected by first dividing the change in model PI by the absolute value of the change in the forcing ratio and then checking to see if the quotient is less than one. As long as this quotient is less than one, the System Index will perform in the desired manner.

D. USING THE SYSTEM INDEX

A history of indices can easily be created from historical fitness report data files. The indices can then be graphed versus time to create a visual picture of how the two-decision model has responded to factors affecting promotion decisions. A declining trend in the magnitude of the indices will indicate either that inflation is becoming a problem or that "combat" factors are becoming important

to the decision process. The forcing ratio can be used to determine whether or not inflation is causing the trend.

For example, assume that the system indices for the major's promotion board have decreased steadily since 1979. In 1984, an analyst is asked to determine whether or not fitness report inflation is affecting the promotion process for major.

The analyst can answer this question by comparing the model's performance for, say, the 1979 major's board with what it would have been if the 1979 data were inflated to 1984 levels. To accomplish this, the analyst first adjusts the 1979 data for inflation by adding the difference in means between 1979 and 1984 data to the 1979 data. He then generates a model PI for the 1979 adjusted data. This index represents how the model would have performed if the 1979 promotion board had been forced to base its decisions on data inflated to 1984 levels.

This procedure isolates the effects of inflation because the same promotion board results are used to force a model solution from data sets which are identical except for an adjustment for inflation. A decrease in the model PI generated for the adjusted data indicates that inflation is affecting promotion decisions. The forcing ratio can be used to identify which type of inflation is present.

If little or no decrease is noted, the yearly downward trend must be due to the effect of other factors. Since the

"membership" factor will not cause trends in system indices, "combat" factors similar to those previously discussed must be having some effect. Our analyst concludes that either the model needs adjustment to include additional information that has become important to promotion boards or that fitness reports may be in need of modification.

VIII. COMMENTS AND SUMMARY

Before summarizing there are a few remaining topics that should be discussed.

A. RANK INFLATION

Our study of the 1984 major's promotion board data showed that Marines with the "best" fitness report records were selected for promotion. Assuming that this remains true, subsequent promotion boards will have more difficulty using fitness report data as a discriminator. This is due to the effect of selective retention which can be thought of as a screening process that only allows the best officers to remain on active duty by being promoted.

Selective retention is expected to decrease the model's ability to correctly classify individuals for promotion to the higher ranks because it will reduce the contrast needed by discriminant analysis to distinguish between

individuals. This reduction in contrast can be thought of as "rank" inflation. The two-decision model developed in this study can probably be applied to the mid-level ranks with success. However, further study of rank inflation is needed before the model is used to analyze and monitor promotion at higher levels. Additional variables may be needed to adequately explain promotion decisions when rank inflation is a factor.

A U.S. General Accounting Office study [Ref. 7] reports developing a discriminate analytic model that uses some fitness report data and experience data to predict promotion to the rank of colonel. The GAO model correctly classified 81% of the SELECTS and 73% of the NON-SELECTS for a .77 weighted classification fraction. Since the a priori probability for selection in the GAO data base was about .57, the GAO model was relatively successful. Thus, the addition of explanatory variables containing experience information to our two-decision model may improve results when rank inflation is a factor.

B. ORDINAL DATA USED AS INTERVAL DATA

The data used in this study was either ordinal or nominal; however, it was treated as if it were interval data. Implicit within this usage is the assumption that the difference between any two marking categories has the same meaning as the difference between any other two marking

categories. For example, the meaning associated with a marking of "Below Average" compared to "Average" is assumed to possess the same meaning as a marking of "Excellent" compared to "Outstanding". This may not and probably is not a valid assumption. Various methods exist which can be used to transform data from ordinal to interval scales. Lindsay [Ref. 8] suggests one way this can be done. Transformation of this type may be necessary when the model's performance must be improved. However, the model's high degree of current success suggests that an interval data assumption provides a reasonable approximation for understanding the fitness report marking scale within the range of markings normally assigned to an individual.

C. ADJUSTMENTS FOR INFLATION

"Adjustment for inflation" has previously been described as adding the difference in means between two data sets to the older data set. When predicting promotion data adjustments should be made for each independent variable defined by Equation (2) in order to include "rank" inflation as well as inflation over time. Adjustments made strictly to check the effects of time inflation should not be made for the "reporting senior" and the "truth-teller" which are only subject to "rank" inflation. Furthermore, each promotion zone should be treated separately with an adjustment made for each zone.

D. SUMMARY

The promotion decision is made with two distinctly different sets of criteria. The first set of criteria defines a decision rule for promotion and the second set defines a different rule for promotion passover. Although early fitness reports seem to have considerable impact when a promotion board makes the passover decision, they are not particularly important when a board makes the opposite decision.

Fitness report information is the primary basis upon which promotion boards make either decision. Other information such as personal knowledge about a Marine by a promotion board member either has minimal effect or is represented implicitly within the Marine's fitness report markings.

Inflation over time has apparently not yet interfered significantly with a promotion board's ability to make its decision to promote an individual (at least, through the rank of major). However, early less inflated fitness reports have considerable impact on the decision NOT to promote an individual.

Selective retention causes "rank" inflation; i.e., the average colonel has better fitness report markings than an average major because he has already successfully passed two additional screenings. "Rank" inflation will probably decrease both a promotion board's and the model's ability

to discriminate between individuals on the basis of fitness report information.

Promotions (or passovers) can be predicted from fitness report data adjusted for inflation. A probability of promotion and a confidence interval can be established for each prediction.

Finally, since the factors which affect promotion decisions will also affect the model's performance, the System Index defined by Equations (4), (5), (7), and (13) can be used to monitor the performance evaluation system.

APPENDIX A: DATA

The data used in this study included all fitness report information about every Marine considered for promotion to the rank of major in 1984. Raw data contained all quantifiable fitness report information about a particular Marine and whether or not he was selected for promotion.

A. TEST DATA

A data sample of 28,777 observed fitness reports was used to study the results of the Texas A&M study [See Appendix B]. The data were not transformed in any way. One observation consisted of fitness report information from one report on one Marine without regard to the rank held when the fitness report was written.

B. EXPLORATORY DATA

The same data sample which was used in testing the referenced study was used as exploratory data during factor analysis, composite variable decision, and discriminant analysis; however, the data were transformed prior to use.

First, Item 16 [See Fig. 1] was transformed from a variable with an integer range between zero to nine to a dichotomous variable, particularly desire = one, other = zero. This transformation was made to represent more realistically the category's meaning in the minds of both

raters and promotion board members. In spite of contrary labeling, a mark of anything other than "particularly desire" is widely considered to be a poor evaluation.

Item 15a (general value....) was combined with Item 15b (distribution of all....) to form a new variable denoted as the "truth-teller". This transformation was necessary because the "truth-teller" is calculated and provided to each selection board. The "truth-teller" takes on values between zero and is calculated as follows:

$$TT = \frac{w + b}{b + (2*w) + a}$$

where "w" is the number of individuals rated with a Marine (minus one); "a" is the number rated above the Marine; and "b" is the number rated below the Marine. Since the "truth-teller" is scaled between zero and one with zero being bad and one good, the "truth-teller" possessed meaning which was consistent with other data.

Item 17a (commendatory) is a nominally scaled variable which takes on a value of zero if a commendation is included with the fitness report and one if one is not included. Item 17a was also transformed to make its scale consistent with other data:

Commendatory = 1-Commendatory

Finally, all fitness report markings were averaged for each individual (except for Items 15a and 15b). Thus, one observation consisted of fitness report information

averaged by category over all fitness reports for one Marine. In a sense, an average fitness report was generated --profiling each Marine. This transformation was needed to reduce the "noise" in discriminant analytic results. For example, a Marine might have had one "bad" fitness report and still be selected for promotion because of many other exemplary reports. If this "bad" report were used to explain why he was selected for promotion, unnecessary variance would confuse results.

Some consideration was given to weighting fitness reports differently depending on recentness and length of reporting period. However, the model appears to discriminate well without resorting to arbitrary weighting schemes. It should be noted that fitness reports written on second lieutenants, for example, are weighted equally with reports written on captains ten years later. Observed fitness reports covering one month are equally weighted with reports covering six months.

Prior to use in discriminant analysis part of the exploratory data base was again transformed to insure that each averaged category marking possessed equivalent scales. For example, the averaged marking for "regular duties" is continuous, taking on values between zero and nine. In contrast, the averaged marking for "commendatory" assumes values between zero and one. The magnitude of the scale associated with the "commendatory" category was transformed

by multiplying averaged "commendatory" observations by nine. Similarly items 16,17,19, and the "truth-teller" were transformed to make each variable in the discriminant analytic model possess an equivalent range of magnitude.

APPENDIX B: RESULTS, IMPACT & EXTENSION OF THE TEXAS A&M PAPER

A Texas A&M paper [Ref.3] reports using factor analysis to analyze fitness report data in order to answer several questions and make recommendations concerning a new fitness report form. Two of the questions answered by the paper are pertinent to this study.

A. RESULTS

One question concerned the number and nature of the dimensions underlying the first twenty-two fitness report marking categories. A sample of fitness report data was factored for four ranks--sergeant, gunnery sergeant, lieutenant, and major. Initially, all marking categories were found to load on one factor. "General value to the service" was partialled out of the correlation matrix and the analysis was repeated. Four dimensions or factors emerged and are presented in Table B-1. "Growth" and "administrative duties" did not load on any factor.

A second question addressed by the Texas A&M paper was whether or not the same factor structure existed for each rank. In order to answer this question, the referenced study reports sorting and factoring the data by rank. Factors emerged which were essentially the same as those presented in Table B-1. These results indicated that factor

structures were essentially the same across ranks as well as within ranks.

TABLE B-1:FACTOR LOADINGS - TEXAS A&M STUDY:TEST DATA

FACTOR	ITEM	LOADINGS TEXAS A&M	LOADINGS TEST DATA
1	Handling Enlisted	.69	.73
	Leadership	.61	.67
	Force	.60	.56
	Judgement	.57	*.37*
	Training Personnel	.53	.50
	Economy of Management	.51	*.28*
2	Attention to Duty	.74	.72
	Regular Duties	.69	.58
	Initiative	.59	.58
3	Cooperation	.75	.75
	Loyalty	.71	.51
	Personal relations	.70	.72
4	Personal Appearance	.84	.83
	Military Presence	.75	.70
5	Judgement		.42
	Economy of Management		.70

B. IMPACT

The Texas A&M paper concluded that a single fitness report form with reduced numbers of dimensions (marking categories) was adequate for rating Marines with ranks between sergeant and major. This finding is important to the present study because it indicates that regardless of a Marine's rank, the raters generally attach the same meaning to the markings they assign. Correlated marking categories are therefore consistent across ranks and can be grouped to form composite variables that possess meaning and which are generally independent of each other. An independence among

explanatory variables ensures that the meaning of the weights determined by a discriminant analytic model more clearly represents the importance that the related variables possess as a composite group in the decision to promote.

C. EXTENSION

The Texas A&M analysis was conducted on a data base differing somewhat with the data base possessed by a promotion board. For example, a promotion board possesses fitness report information about an individual including reports from all lower reportable ranks. Since considerable time may elapse between the time a Marine receives a report as a lieutenant until he receives one as a major, it is possible that the rating concepts (as opposed to marking level) may have changed. The data base used by Texas A&M included only fitness report information about individuals in a particular grade. It was therefore necessary to discover whether or not the results from the Texas A&M study were valid for an appropriate data base.

In order to test these results, the "TEST DATA" described in Appendix A was factored using principle component analysis. Six different rotation techniques with eigenvalues greater than one were tried. Identical factor loadings emerged regardless of the rotation method used.

The results presented in TEST DATA column of Table B-1 are essentially the same as the results obtained by the

Texas A&M study. Although "judgement" and "economy of management" loaded on a different factor using the test data, moderate positive loadings of .37 and .28 were also noted with the first factor. Thus, the differing categories would probably have loaded on the first factor if a separate factor had not emerged. In general, Table B-1 shows that factor placement results were the same for both studies and serves to extend the Texas A&M results to cover a data base appropriate for this paper.

An additional analysis was necessary to insure that the results from the referenced study were equally valid for averaged data as described in "Exploratory Data" of Appendix A. The exploratory data were first averaged by category for each individual and then factored using the previous method. Again, results were in accordance with the referenced study.

APPENDIX C: COMPUTER PROGRAM

This appendix contains a listing of the SAS program used to transform fitness report data, create observations, and solve the the two-decision model developed in this paper. Lines 9, 152, and 153 summarize data transformations discussed in Appendix A. Lines 10 through 67, 95 through 98, and 152 compute the "truth-teller". Lines 91 through 94 average fitness report data. Lines 99 through 154 show how observations were compiled from the transformed data. Finally, the SAS steps needed to solve the model are listed beginning at line 158.

A. PREPARATION

A data file containing all fitness report information about any individual considered for promotion by a particular promotion board was created from the USMC Fitness Report Historical File. The data file was first merged (by social security number) with a file containing lineal numbers and then with a file containing selection information. A SAS data set was then created. Only lineal number (LINEAL), selection information (SEL), reporting senior grade (RSGRADE), and Section B fitness report markings from items 12 through 19 (self-evident nomenclature) were retained in this data set.

B. SAS PROGRAM

```
 1.  DATA DISCRIM;
 2.     SET FITREP.INFO;
 3.        IF CASE NE 0 THEN DELETE;
 4.        IF LINEAL GE 36930 THEN DELETE;
 5.        IF LINEAL GE 35978 AND LINEAL LT 36930
              THEN ZONE='IN_ZONE';
 6.        IF LINEAL LT 35978 THEN ZONE='ABOVE_ZONE';
 7.        IF SELECT='N' THEN SELECT=0;
 8.        IF SELECT='S' THEN SELECT=1;
 9.        COMMEND=(1-COMMEND)*9;
10.        WITH=ABOVE=BELOW=.;
11.        IF I15A GT . THEN DO;
12.           TOTAL=SUM(UN,BA,BAAV,AVG,AVAA,AA,AAEX,
                    EX,EXOS,OS);
13.              IF TOTAL GT 1 THEN DO;
14.                 IF I15A=9 THEN DO;
15.                    WITH=OS-1;
16.                    ABOVE=0;
17.                    BELOW=SUM(UN,BA,BAAV,AVG,AVAA,
                          AA,AAEX,EX,EXOS);
18.                 END;
19.                 IF I15A=8 THEN DO;
20.                    WITH=EXOS-1;
21.                    ABOVE=OS;
22.                    BELOW=SUM(UN,BA,BAAV,AVG,AVAA,
                          AA,AAEX,EX);
23.                 END;
24.                 IF I15A=7 THEN DO;
25.                    WITH=EX-1;
26.                    ABOVE=SUM(EXOS,OS);
27.                    BELOW=SUM(UN,BA,BAAV,AVG,AVAA,
                          AA,AAEX);
28.                 END;
29.                 IF I15A=6 THEN DO;
30.                    WITH=AAEX-1;
31.                    ABOVE=SUM(EX,EXOS,OS);
32.                    BELOW=SUM(UN,BA,BAAV,AVG,AVAA,
                          AA);
33.                 END;
34.                 IF I15A=5 THEN DO;
35.                    WITH=AA-1;
36.                    ABOVE=SUM(AAEX,EX,EXOS,OS);
37.                    BELOW=SUM(UN,BA,BAAV,AVG,AVAA);
38.                 END;
39.                 IF I15A=4 THEN DO;
40.                    WITH=AAAA-1;
41.                    ABOVE=SUM(AA,AAEX,EX,EXOS,OS);
42.                    BELOW=SUM(UN,BA,BAAV,AVG);
43.                 END;
```

```
44.                  IF I15A=3 THEN DO;
45.                     WITH=AVG-1;
46.                     ABOVE=SUM(AAAV,AA,AAEX,EX,EXOS,
                           OS);
47.                     BELOW=SUM(UN,BA,BAAV);
48.                  END;
49.                  IF I15A=2 THEN DO;
50.                     WITH=BAAV-1;
51.                     ABOVE=SUM(AVG,AAAV,AA,AAEX,EX,
                           EXOS,OS);
52.                     BELOW=SUM(UN,BA);
53.                  END;
54.                  IF I15A=1 THEN DO;
55.                     WITH=BA-1;
56.                     ABOVE=SUM(BAAV,AVG,AAAV,AA,
                           AAEX,EX,EXOS,OS);
57.                     BELOW=UN;
58.                  END;
59.                  IF I15A=0 THEN DO;
60.                     WITH=UN-1;
61.                     ABOVE=SUM(BA,BAAV,AVG,AAAV,AA,
                           AAEX,EX,EXOS,OS);
62.                     BELOW=0;
63.                  END;
64.               ELSE A=ABOVE B=BELOW W=WITH;
65.               END;
66.            ELSE A=ABOVE B=BELOW W=WITH;
67.            END;
68.      REG_DUTY=I13A ADD_DUTY=I13B ADM_DUTY=I13C;
69.      HAND_OFF=I13D HAND_ENL=I13E TRAINING=I13F;
80.      APPEAR=I14B   PRESENCE=I14C ATT_DUTY=I14D;
81.      COOPER=I14E   INITIAT=I14F  JUDGE=I14J;
82.      FORCE=I14I    LEADERS=I14J  LOYALTY=I14K;
83.      PER_REL=I14L  ECON_MAN=I14M GROWTH=I14N;
84.      GVS=I15A      TAC_HAND=I13G ENDUR=I14A;
85.      PRE_MIND=I14H;
86.      ABOVE=A BELOW=B WITH=W;
87.      KEEP  REG_DUTY ADD_DUTY ADM_DUTY HAND_OFF
               HAND_ENL TRAINING APPEAR   PRESENCE
               ATT_DUTY COOPER   INITIAT  JUDGE
               FORCE    LEADERS  LOYALTY  PER_REL
               ECON_MAN GROWTH   GVS      TAC_HAND
               ENDUR    PRE_MIND SELECT   RSGRADE
               ABOVE    BELOW    WITH     ZONE
               lineal;
88.      PROC SORT;
89.         BY ZONE LINEAL;
91..     PROC SUMMARY;
92.         BY ZONE LINEAL;
93.         VAR REG_DUTY ADD_DUTY ADM_DUTY HAND_OFF
                HAND_ENL TRAINING APPEAR   PRESENCE
```

```
                ATT_DUTY COOPER   INITIAT  JUDGE
                FORCE    LEADERS  LOYALTY  PER_REL
                ECON_MAN GROWTH   GVS      TAC_HAND
                ENDUR    PRE_MIND SELECT   RSGRADE;
 94.          OUTPUT OUT=AVE_MARKS MEAN=;
 95.       PROC SUMMARY;
 96.          BY ZONE LINEAL;
 97.          VAR ABOVE BELOW WITH;
 98.       OUTPUT OUT=TT_SUMMARY SUM=ABOVE BELOW WITH;
 99.    DATA MODEL;
100.       MERGE AVE_MARKS TT_SUMMARY;
101.          BY ZONE LINEAL;
102.       NALL=N1=N2=N3=N4=N5=.;
103.       IF HAND_ENL NE . THEN N1=1;
104.       IF LEADERS NE . THEN N2=1;
105.       IF FORCE NE . THEN N3=1;
106.       IF TRAINING NE . THEN N4=1;
107.       IF HAND_OFF NE . THEN N5=1;
108.       NALL=SUM(N1,N2,N3,N4,N5);
109.    X1=SUM(HAND_ENL,LEADERS,FORCE,TRAINING,
              HAND_OFF)/NALL;
110.       NALL=N1=N2=N3=.;
111.       IF ATT_DUTY NE . THEN N1=1;
112.       IF INITIAT NE . THEN N2=1;
113.       IF COMMEND NE . THEN N3=1;
114.       NALL=SUM(N1,N2,N3);
115.    X2=SUM(ATT_DUTY,INITIAT,COMMEND)/NALL;
116.       NALL=N1=N2=N3=.;
117.       IF COOPER NE . THEN N1=1;
118.       IF LOYALTY NE . THEN N2=1;
119.       IF PER_REL NE . THEN N3=1;
120.       NALL=SUM(N1,N2,N3);
121.    X3=SUM(COOPER,LOYALTY,PER_REL)/NALL;
122.       NALL=N1=N2=.;
123.       IF APPEAR NE . THEN N1=1;
124.       IF PRESENCE NE . THEN N2=1;
125.       NALL=SUM(N1,N2);
126.    X4=SUM(APPEAR,PRESENCE)/NALL;
127.       NALL=N1=N2=N3=N4=.;
128.       IF JUDGE NE  . THEN N1=1;
129.       IF ECON_MAN  NE . THEN N2=1;
130.       IF ADM_DUTY NE. THEN N3=1;
131.       IF PROMOTE NE . THEN N4=1;
132.       NALL=SUM(N1,N2,N3,N4);
133.    X5=SUM(JUDGE,ECON_MAN,ADM_DUTY,(PROMOTE*9))/NALL;
134.       NALL=N1=N2=N3=.;
135.       IF REG_DUTY NE . THEN N1=1;
136.       IF GROWTH NE . THEN N2=1;
137.       IF PDSIRE NE . THEN N3=1;
138.       NALL=SUM(N1,N2,N3);
139.    X6=SUM(REG_DUTY,GROWTH,PDSIRE)/NALL;
```

```
140.      NALL=N1=N2=.;
141.      IF DISCIPL NE . THEN N1=1;
142.      IF ADVERSE NE . THEN N2=1;
143.      NALL=SUM(N1,N2);
144.   X7=SUM(DISCIPL,ADVERSE)/NALL;
145.      NALL=N1=N2=N3=.;
146.      IF TAC_HAND NE . THEN N1=1;
147.      IF ENDUR NE . THEN N2=1;
148.      IF PRE_MIND NE. THEN N3=1;
149.      NALL=SUM(N1,N2,N3);
150.   X8=SUM(TAC_HAND,ENDUR,PRE_MIND)/NALL;
151.   X9=ADD_DUTY;
152.   TT=(SUM(BELOW,WITH)/SUM(ABOVE,2*WITH,BELOW));
153.   X10=TT*9;
154.   X11=RSGRADE;
155.   IF SELECT=0 THEN CATEG='NON_SELECTS';
156.   IF SELECT=1 THEN CATEG='SELECTS';
157.   KEEP X1,X2,X3,X4,X5,X6,X7,X8,X9,X10,X11,
         CATEG ZONE;
158.   PROC DISCRIM DATA=MODEL SIMPLE;
159.      CLASS CATEG;
160.      PRIORS PROPORTIONAL;
161.      BY ZONE;
```

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